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MATHEMATICAL MODELING OF MULTIPHASE FILTRATION IN POROUS MEDIA WITH A CHEMICALLY ACTIVE SKELETON

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The authors propose a mathematical model of two-phase filtration that occurs under the conditions of dissolution of a porous medium. The model can be used for joint description of complex chemical-hydrogeomechanical processes that are of frequent occurrence in the oil-and-gas producing and nature conservation practice. As an example, consideration is given to the acidizing of the bottom zone of the injection well of an oil reservoir. Enclosing rocks are represented by carbonates. The phases of the process are an aqueous solution of hydrochloric acid and oil. A software product for computational experiments is developed. For the numerical experiments, use is made of the data on the wells of an actual oil field. Good agreement is obtained between the field data and the calculated data. Numerical experiments with different configurations of the permeability of an oil stratum are conducted.

Keywords: *mathematical model, two-phase filtration, deformable porous medium, chemically active fluid, skin factor.*

Introduction. The processes of filtration of chemically active and aggressive liquids have long been the subject of investigations of hydrorheology and hydromechanics by virtue of the relevance of technologies that require the injection of chemically active fluids or of environmental problems associated with the leaks of chemically active fluids. A widely known example of the technology of injection of an aggressive fluid is the acidizing of the bottom zone of producing wells at oil fields. An example of the environmental problem associated with the migration of aggressive liquids is the formation, at a number of fields, of sulfuric acid from sulfur and hydrogen sulfide, by-products of oil or gas extraction, with their subsequent oxidation to sulfuric acid. Poor technological solutions on utilizing this product may lead to a pollution of the hydrosphere with extremely unfavorable effects caused by both the deviation of the composition of groundwater from required conditions and the sulfur-acid action on underground engineering structures. One difficult point in modeling such processes is the impossibility of using chemical-kinetics relations directly in the equations of underground mass transfer. This is due to the fact that in chemical kinetics, the solution in which reactions proceed is physically kept under ideal-mixing conditions as a rule. Descriptions of filtration and migration are carried out on the scale of the representative volume of a porous medium, and it often remains unclear whether the concentrations of the reactants in this volume are physically equalized. This problem is not necessarily solved successfully by making the grid step smaller, since there is the constraint imposed by the medium′s representative volume. This problem is pressing in the cases where the reaction front is sharp and falls within one computational call.

An additional factor making it difficult to model such processes is accounting for the deformations of a porous skeleton with its subsequent influence on the filtration and hence mass transfer of an aggressive fluid and its reaction with the substance of the porous skeleton. In some cases, such as the acidizing of the well bottom zone in carbonate reservoirs, chemical interaction between the acid and the rock is particularly violent, which produces substantial changes in the porosity and permeability of the rocks of the reservoir bed. Under these conditions, it seems impossible to neglect the deformation of the porous skeleton.

The present article seeks to analyze interrelated processes of multiphase filtration and mass transfer of a chemically active fluid and of deformation of rocks in the process of reaction between the substance of the rocks and the fluid. These questions were analyzed in [1]; however, the example realized in [1] was considered for the case of single-phase multicomponent filtration. In the present article, we give an example for the case of two-phase filtration. The prime objective of the work is to construct and check a mathematical model that describes simultaneous processes of hydrogeomechanics and geochemistry.

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